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INTERNATIONAL GEOPHYSICAL COOPERATION PROGRAM —

SOVIET-BLOC ACTIVITIES

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I. ROCKETS AND ARTIFICIAL EARTH SATELLITES

Four Soviet Scientists Look to the Future

Flight to the Nearest Star

A recent issue of the Soviet publication Izobretatel' i Ratsionalizator contains a number of articles in which prominent Soviet scientists express their ideas about future scientific developments.

Professor K. P. Stanyukovich, Doctor of Technical Sciences (his picture is included in the original text) is one of those writing in this article for popular consumption.

"In 1955," he writes, "there was a meeting of the International Congress on Interplanetary Communication. It outlined a program for overcoming space within the next few decades. According to this program Man should reach the surface of Mars between 1978 and 1985 — but it is possible that the rapid progress of science will considerably shorten this time."

"Until quite recently," he adds, "the idea of an interstellar space ship seemed like a wild dream. Our nearest neighbor in the heavens -- Proxima Centaura — is situated 40 trillion kilometers away. Even if we devise a rocket whose velocity is 10 times greater than that of our artificial earth satellites, it would still require 10,000 years to make the flight."

"Such a flight would require an immense amount of ordinary fuel. Even an atomic rocket powered by a motor based on a controlled thermonuclear reaction cannot serve as a stellar space ship. But a still more powerful motor than this is possible — a motor using light as fuel."

"With atomic rockets we may get a velocity of hundreds or possibly even thousands of kilometers per second. But this is too little for a stellar space ship. Light, however, possesses the maximum possible velocity in nature. A light ray travels the tremendous distance separating us from Proxima Centaura in 4.3 years. This means that if we succeed in using light as a 'fuel' we will have created the most powerful motor possible."

"Let's imagine that light rays fall on an immense reflector and are then reflected. The pressure of the light in space that is free of air and gravitation will force the space ship to move. The light source must be of enormous power."

"In recent years scientists have learned of the existence of so-called antiparticles and have even been able to produce some artificially. By antiparticles we mean those particles which have the same mass as ordinary particles but have a charge of the opposite sign. A proton is a particle with a positive charge, while an antiproton is negative. A neutron does not possess an electrical charge but it differs from an antineutron by its direction of rotation. Matter that consists of antiparticles is called antimatter. Antiparticles on meeting with ordinary particles 'disappear,' being transformed into a stream of light: a stream of photons and other particles. At this time energy is liberated, a hundred times more than during a thermonuclear reaction. This means that in principle it is possible to create a photon rocket -- a rocket using light as its fuel."

"The difficulties of building such a rocket are enormous. It would have to be very large, possibly a thousand kilometers long. This is necessary in order to keep the crew away from the mirror. The rocket would have to be built somewhere in space, under conditions of weightlessness. The launching of the rocket cannot be accomplished from the Earth because the powerful radiation would burn the Earth's surface for many kilometers around."

"The reflection of the rays is a very complex problem. It is well known that the best mirrors do not reflect light completely; they absorb part of the energy and thereby become heated. It has been calculated that for the creation of a pressure of one atmosphere per square centimeter the reflector should receive every second a stream of light with an energy capable of bringing 10 tons of water to a boil. Therefore the mirror should possess an enormous reflecting capacity if it is not to fail in service."

"It is possible that in place of the extremely turbulent reaction of the combination of matter and antimatter there will be found a calmer but equally powerful source of radiation of electromagnetic energy. Then many problems will become far simpler."

"When we discuss the photon rocket we are not thinking of the next few decades, but about the extremely distant future. Of course, quite recently it seemed fantastic to think of the possibility of liberating atomic energy and making interplanetary flights!"

Time in Space

Academician L. D. Landau and Professor Yu. B. Rumer then discuss a different aspect of space travel.

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"As is known from the theory of relativity, clocks that are at a state of rest go more rapidly than those that are moving. This principle will be applicable if we do succeed in flying at speeds approaching the speed of light."

"The figures would seem to be consoling," they write, "for three years spent in the rocket will be equal to 360 years on Earth! But things are not so rosy in respect to the expenditure of energy. The energy consumed by a modest-sized rocket (1 ton) when flying at a velocity of 260,000 km a second (the velocity necessary to 'double' time — that is, for each year of travel in the rocket to equal two years on Earth) is 250,000,000,000,000 kilowatt hours. This is as much energy as produced on the entire globe in a period of several months. This is only the energy needed in flight — we have not considered how much it would take to bring our ship to a velocity of 260,000 km a second! Nor have we considered how much is needed for the braking process at the end of the journey for a safe landing."

"Even if we had a fuel giving a jet which leaves a jet motor with the greatest of all possible velocities, that is, with the speed of light, this energy would have to be 200 times greater than that mentioned above. That is, we would have to expend as much energy as mankind produces in several decades."

Artificial Earth Satellites for Use in Television

Professor P. V. Shmakov then continues with praise for Soviet specialists who solved the technical problems of transmitting television pictures from outer space. Looking into the future, he visualizes a day when there will be three artificial earth satellites with television relaying stations; these will rotate from west to east in a circular orbit at a distance of 35,810 km above the Earth in the plane of the equator. These artificial satellites will have a period of rotation of 24 hours, that is, equal to that of the Earth's rotation. They will seemingly hover in space over a given point on the Earth's surface. The three satellites will be 8 hours in time distant from one another. They will make it possible for us to have a universal television system, for the feasibility of sending television pictures through space has already been convincingly demonstrated. ("Dreams of the Future of Science and Technology," by K. P. Stanyukovich, L. D. Landau, Yu. B. Rumer and P. V. Shmakov, Izobretel' i Ratsionalizator, No. 1, 1960, pp. 15-18 and 21-23)

Projected Soviet Cosmic Flights Discussed by Poles

An article in Zolnierz Polski, mentions the next alleged Soviet space probes, to Venus and Mars. The former reportedly will be launched to the vicinity of the planet Venus and the latter, a "space reconnaissance" rocket, will investigate the environs of Mars.

 According to the article, "two flight paths already outlined by astronomers" will be used for the proposed flight of manned rockets to Mars and their return to Earth. Accompanying the article is a drawing showing the two flight paths, which are referred to as path "A" and path "B", and the paths of the Sputniks and Luniks which have thus far been launched. Path "A" is almost parallel to the Earth's orbit and path "B" is almost a direct line to the planet Mars. According to the figures of astronomers, the flight along path "A" will require 32 months and the flight on path "B", 5 months and 3 days, including a 13-day stay on Mars, the article adds.

Regarding the original title of the article, the importance of the initial experiment by Kontanty Tsiolkovskiy, the "father of contemporary astronautics," to space travel research, is pointed out, citing the current training of US astronaut candidates in steel containers filled with water. ("Astronauts and the Egg," Unsigned article, Warsaw, Zolnierz Polski, No. 4 (609), 21-27 Jan. 1960, p. 6)

II. UPPER ATMOSPHERE

Origin of the Outer Radiation Belt

The following is a letter to the editor of the Astronomicheskiy Zhurnal concerning the origin of the Earth's outer radiation belt. The author is S. B. Pikel'ner of the Physics Faculty of the Moscow State University "M. V. Lomonosov":

"As has been established, the Earth's outer belt is essentially made up of electrons with an energy on the order of several thousand ev and above. As of now their origin is unknown. It has been surmised that their origin is associated with geoactive streams of corpuscles. This letter proposes one of the possible mechanisms for such a connection. The penetration of currents of corpuscles into the Earth's field was considered in a previous paper by the undersigned. Plasma, decelerated by the field, is instable and the flat front must break into individual streams which will approach the Earth. At this time they are compressed by the field; this decreases diamagnetic repulsion and permits blobs of plasma to approach practically to the boundaries of the atmosphere. The action of the magnetic field should deflect the blobs in the direction of the high latitudes. The compression of the blob leads to a heating of the gas to a temperature of 5-30 million degrees. This value depends on assumed initial conditions and essentially is determined only by the initial kinetic energy of the current which is transformed into thermal energy. Collisions between particles at a high energy cannot occur, and the internal energy of the gas will increase on reflection from the walls of the element as in the Fermi mechanism and due to the induced action of the compressed inner field of the element."

"The degree of compression and the depth of penetration of the element depends on the initial temperature of the gas. If it is low (5,000-10,000°), then the element is compressed ten times and can almost approach the boundaries of the atmosphere. If the initial temperature is high, however, then the element remains at a distance from the Earth, but the chaotic energy of the particles in this case will also be increased considerably. Inasmuch as the current approaches the Earth in the form of a shock wave, the temperature behind the front should already be on the order of 20-30 million degrees; as Parker has shown, electron temperature should be of this same order. Therefore the compression of the element will increase the energy of both ions and electrons. The final energy can attain 5 kev and more. If the temperature behind the front T_0 is determined by the energy of the current, then after compression and the stopping of the element it is equal to $1.6\ T_0$. In order that the particles enter into the radiation belt, they should move from the element of the current into the Earth's field

and without expenditure of work against the pressure of the field. Within the element there is also a field and the pressure could deform it. The particles can leave the element due to drift into a nonhomogeneous field." ("Concerning the Origin of the Earth's Outer Radiation Belt," by S. B. Pikel'ner, Astronomicheskiy Zhurnal, Vol. 36, No. 6, Nov.-Dec. 1959, p. 1134)

III. METEOROLOGY

Study of Cyclonic and Anticyclonic Tracks in the Southern Hemisphere

This article gives some generalizations in respect to the movement of cyclones and anticyclones in the Southern Hemisphere during the summer season of 1955/1956 and the winter season of 1956. For this purpose the Southern Hemisphere was divided into three sectors: Atlantic (70° W. - 20° E.), Indian Ocean (20° E. - 120° E.) and Pacific (120° E. - 70° W.).

Figure 1 (not reproduced here) shows the tracks of cyclones and anticyclones in the summer of 1955/1956. They encircle the Antarctic continent in a tight ring in the limits of 50-60° S. Figure 1 shows that many cyclone tracks veer from this mainstream toward the Antarctic continent.

The pattern of cyclone tracks in the winter season (Figure 2) differs somewhat from the pattern for the summer season. In winter cyclonic movement is characteristically north - south. Compact groups of cyclone tracks approach the Antarctic coast after curving in a clockwise direction. There are two regions in the Atlantic sector where such cyclones originate, while there are five such regions in the Pacific Ocean.

A joint examination of the patterns of summer and winter cyclonic movement enables us to draw some conclusions.

1. The numerous closely parallel cyclones easily noticeable in the summer do not appear so clearly in the winter inasmuch as north - south circulation is more sharply expressed. At this time we observe more frequent and powerful intrusions of cold from the high latitudes into the low latitudes and more intense cyclogenesis on the polar fronts in the subtropical and temperate latitudes, especially to the southeast of all the continents.

2. The cyclones pass farther to the south in the Indian Ocean sector in summer than in winter and the cyclonic tracks are farthest south in February.

3. In the Pacific Ocean sector in the winter in the vicinity of 60° S. and 150° E. the cyclone tracks fork in two directions — some toward the Ross Sea and others toward the central region of the southern part of the Pacific Ocean, so that these tracks tend to have a more pronounced north - south orientation than in the summer.

4. The patterns for both seasons show that the cyclone tracks approach the Antarctic continent in the vicinity of the Weddell Sea, to the west and east of Enderby Land, and to the west and east of the Davis Sea, Adele Land, the Ross Sea and in places to the north of Bellingshausen Sea.

One author suggests the existence of six cyclonic regions: over the Weddell Sea, Queen Maud Land, over the Mackenzie Sea, the Knox Coast, George V Land and over the Ross Sea.

The mean velocities of movement of cyclones in the winter season are considerably greater than in the summer — about 50 km/hr, rather than about 43 km/hr for the warmest months (this article does not deal with cyclones and anticyclones over the continent, but only over the surrounding seas).

In the Indian Ocean sector cyclones move more rapidly than elsewhere, those in the Atlantic occupy an intermediate position, while those in the Pacific Ocean move the least rapidly. Tables 1 and 2 give the mean velocities of cyclones in winter and summer, by month and by sector.

The anticyclones of the Southern Hemisphere are more mobile than the subtropical anticyclones of the Northern Hemisphere. Figures 1 and 2 graphically show the tracks followed by anticyclones in summer and winter, while Tables 1 and 2 provide the same data for the mean velocities of anticyclones as for cyclones.

By comparing data concerning anticyclones in the summer and winter seasons, we can point out some specific characteristics.

1. In winter the concentration of tracks of anticyclones of the subtropical zone shifts to the north by about 5° in comparison with the situation of these tracks in the summer. This northward shift is 8° or more in parts of the Indian and Pacific Oceans (near Madagascar, Eastern Australia and the eastern part of the Pacific Ocean).

In the Atlantic sector the tracks of the anticyclones begin in approximately the same latitudes (about 30° S.) in both seasons.

2. The data in Tables 1 and 2 show that in winter the anticyclones of the subtropical zone move with greater velocities than in the summer.

3. It may be noted that in the course of the year polar intrusions occur from various regions in Antarctica. Some of the most characteristic regions from which they originate are Coates Land, Queen Maud Land, Wilkes Land, Victoria Land and Marie Byrd Land.

Table 3 gives the frequency of polar intrusions during the summer season by point of origin and by month.

These anticyclones, penetrating far to the north, disrupt zonal circulation in this region; cyclones moving from west to east must either bypass these regions of high pressure on the north or, when approaching

them, change their direction sharply to the south, slow down, become increasingly immobile near the shores of Antarctica and gradually die out. In other cases the blocking action of anticyclones leads to the disruption of zonal circulation over a rather great area. ("Directions of Movement of Cyclones and Anticyclones in the Southern Hemisphere," by L. A. Zhdanov, Meteorologiya i Gidrologiya, No. 1, 1960, pp. 10-17)

Vertical Currents in the Troposphere

Vertical movements of air masses, playing an important role in the formation of cloudiness and the genesis of precipitation, belong to that class of phenomena which cannot be measured directly but are instead determined by computations, by means of integration of the equations of hydrothermodynamics.

This article gives the approach and equations to be used in the prediction of vertical currents at three levels in the troposphere; this is part of the more general problem of prediction of a number of meteorological elements by use of a computer.

An analysis of the fields of vertical currents at different levels within the troposphere and the statistical processing of vertical velocities has enabled us to get their mean characteristics, to evaluate the role and significance of the various factors forming these currents, to check the barotropic hypothesis and consider the vertical and horizontal structure of the currents. ("Vertical Currents in the Troposphere," P. K. Dushkin and Ye. G. Lomonosov, Meteorologiya i Gidrologiya, No. 1, 1960, pp. 3-9)

Processes in the Development of Cumulus and Cumulonimbus Clouds

It is well known that the development of cumulus and cumulonimbus clouds is associated with convectional uplift of air. The vertical velocities arising at this time attain 15 m/sec in cumulus clouds and 30-40 m/sec in thunderheads. We know that there is a much greater mass of air in such clouds than flows in through its base. This article is concerned with horizontal entrainment, in which air that is situated above a cumulus or cumulonimbus cloud is drawn into the horizontal flow. For an evaluation of the role of this mechanism, new for meteorologists, the author of this article tries to qualitatively evaluate some possible consequences of this action. ("The Mechanism of Horizontal Entrainment of Air and its Possible Role in the Development of Cumulus and Cumulonimbus Clouds," V. P. D'yachenko, Meteorologiya i Gidrologiya, Vol. 1, 1960, pp. 34-37)

Radar Sounding of the Atmosphere

Two Soviet scientists, writing in broad terms in the Soviet aviation publication Grazhdanskaya Aviatsiya, describe the use of radar reflectors in meteorological sounding of the atmosphere. Tracking these reflectors by radar sets on the ground and in aircraft yields significant atmospheric data. They recommend that data be cross-checked by simultaneous meteorological observations in aircraft or by radiosondes. They feel that the use of these reflectors is especially promising for the study of vertical air currents and turbulency at all levels, including the stratosphere. ("Radar Sounding of the Atmosphere," by M. Sheynin and A. Yakovlev, Grazhdanskaya Aviatsiya, No. 1, January 1960, p. 14)

Automatic Meteorological Station in the Sea of Okhotsk

The small and uninhabited rocky Iona Islands are situated in the storm-swept Sea of Okhotsk. For a long time their exact geographical position was uncertain and some even questioned their existence. Recently, however, a station situated on one of these islands has begun to send out precise weather reports by radio four times each day. These reports are sent to a meteorological station on the coast and are then relayed to Vladivostok. Within a few minutes a weather summary of conditions in the center of the Sea of Okhotsk is in the hands of ships' crews, airmen and Far Eastern fishermen.

This is all made possible by an automatic meteorological station. It records and communicates by a radiotelegraphic code information concerning pressure and air temperature, the direction and mean velocity of the wind, the amount of precipitation and the percentage of overcast.

The station was built under difficult working conditions last summer on the largest of the islands on a hill 150 meters above sea level. The work required more than a month. ("Meteorological Station on an Uninhabited Island," Pravda, 20 February 1960, p. 4)

Picture of Zvenigorod Scientific Station

A photograph which appears on the back cover of 10 January issue of the Soviet periodical, Ogonek, shows station personnel conducting observations on atmospheric scattering of light using a specially designed spectrometer.

The caption states the picture was taken at the scientific station of the Institute of the Physics of the Atmosphere, Academy of Sciences of the USSR, near Zvenigorod [west of Moscow]. (Moscow, Ogonek, No. 2, 10 Jan. 1960)

IV. GRAVIMETRY

Relationship Between Bouguer Gravitational Anomalies and the Thickness of the Earth's Crust in the Atlantic Ocean Area

The relationship between gravitational anomalies and the thickness of the Earth's crust has been studied repeatedly. D. A. Andreyev has pointed out an almost linear dependence between Bouguer anomalies and the thickness of the Earth's crust on the continents. Zero values of Bouguer anomalies, according to D. A. Andreyev, correspond to a crustal thickness on the order of 30 km, while a change in crustal thickness of 10 km corresponds to a difference in gravitational anomalies of a mean of 100 mgl.

R. M. Domenitskaya gives an empirical formula which she has derived

$$H = 35(1 - \text{th}0.0037\ \Delta g), \qquad (1)$$

this more precisely reflects the relationship between the thickness of the Earth's crust H and the Bouguer anomalies of Δg on the continents. As shown by the results of deep seismic sounding conducted in Central Kazakhstan under the direction of D. N. Kazanli, the relationship between the thickness of the Earth's crust and Bouguer anomalies corresponds well to the approximate formula supplied by R. M. Dominitskaya

$$H = 35 - 0.126\ \Delta g, \qquad (2)$$

which is derived with small values $0.0037\ \Delta g$, that is, in a range of $\pm$200 mgl, and expresses the linear dependence between the thickness of the flat-lying attracting layer and the gravitational anomaly caused by this layer. The computation of the depth of the Mohorovicic discontinuity from formula (1) gives, in comparison with depths determined by the seismic method, a mean square error of $\pm$6.3 km, at the same time that the computation by the usual formula for the attraction of an infinitely plane-parallel layer, similar to the simplified formula, leads to a mean square error of about $\pm$2.5 km, that is, it gives better results. Therefore the author prefers to use the second formula.

In 1957 the author of this article used gravimetric data to compute the Mohorovicic discontinuity for several regions of the Atlantic Ocean, based on the results of seismic work accomplished by American researchers in the vicinity of the Bermuda Islands and the Nares Deep. If we assume that gravitational anomalies are caused only by the relief of the Mohorovicic discontinuity, then to compute its depth it is possible to use the well-known formula for attraction of an infinitely plane-parallel layer:

$$H = H_0 - \frac{\Delta g}{2\pi f \sigma} = H_0 - k\Delta g, \qquad (3)$$

where H -- the depth of the Mohorovicic discontinuity at the point investigated; H_0 -- the depth of the Mohorovicic discontinuity at a reference point known from seismic data; Δg -- the difference in Bouguer anomalies at the reference point and the point investigated; σ -- the excess density of the subcrustal layer;

$$k = \frac{1}{2\pi f \sigma} . \qquad (4)$$

If the dependence between the Bouguer anomaly and the thickness of the Earth's crust is known, then formula (4) can be used to determine the excess density of the subcrustal layer σ.

Up to now a number of works have been published which have been devoted to the study of the Earth's crust in oceanic areas by seismic methods. By using more than 50 seismic points in the northern part of the Atlantic Ocean, it is possible to draw up a graph showing the dependence between Bouguer anomalies, computed with the density of the intermediate layer 2.8 g/cm^3, and the depth of the Mohorovicic discontinuity for these points (Figure 1, not reproduced here, is a graph showing the dependence of Bouguer anomalies on the thickness of the Earth's crust in the North Atlantic).

The graph is a straight line, forming an angle with the axis of the abscissa that is noticeably smaller than that on the graph drawn by B. A. Andreyev. The change in gravitational anomalies of approximately 100 mgl corresponds to a change in the depth of the Mohorovicic discontinuity under the Atlantic Ocean by a mean of 3.3 km.

It is interesting to note that a change in the gravitational anomaly by 100 mgl, both on the continents and in the oceans, is caused by an identical relative change in the thickness of the Earth's crust by 22%. On the continents this is caused by a change in crustal thickness of 10 km, which is 22% of the mean thickness of the continental crust (equal to 45 km). On the oceans -- by a change of 3.3 km, which likewise corresponds to 22% of the mean thickness of the oceanic crust (equal to 15 km).

Making use of the relationship between the thickness of the Earth's crust and Bouguer anomalies, derived from the graph (Figure), we get (by use of formula 4) the excess density at the Mohorovicic discontinuity $\sigma = 0.72$ g/cm^3. Consequently, by using the density of basalt $\sigma_1 = 2.8$ g/cm^3, we should consider the density of the substrata to be $\sigma_2 = 3.52$ g/cm^3.

By comparing the graph in Figure 1 with the graph drawn up by B. A. Andreyev, we can see that in an oceanic area a relatively small change in the thickness of the Earth's crust causes a noticeably greater change in gravitational anomalies than on the continents. This is evidently due to the difference in the structure of the two types of earth crust -- oceanic and continental. The oceanic crust consists basically of basalt. The granite layer here is usually absent and the thickness of sediments is very small (no more than 1.5-2 km). Consequently, the gravitational anomalies in the oceans are caused only by a change in the thickness of the basalt layer (density -- 2.8 g/cm^3). Evidently even a small change in the thickness of this layer will cause a considerable change in the gravitational field in the oceans, as we see in the case of the North Atlantic. ("Relationship Between Bouguer Anomalies and the Thickness of the Earth's Crust in the Atlantic Ocean Area," by Yo. D. Koryakin, Moscow State University, Doklady Akademii Nauk SSSR, Vol. 129, No. 6, 1959, pp. 1287-1289)

Hungarian Theory Links Movement of Earth's Core to Gravitational Changes

On 22 January 1960, Dr. Gyorgy Barta, a scientific worker of the Hungarian Geophysical Institute, read a paper before the Geodetic and Cartographic Association (Budapest) in which he presented a new theory based on two observations: (1), that a cross-section of the Earth at the Equator is not round but elliptical; and (2), that the magnetic center of the Earth is not in the geometrical center but is displaced therefrom by 300-400 kilometers. Dr. Barta showed that if the line connecting the geometric and magnetic centers is extended then it reaches the Earth's surface at those two points where the surface bulges out by several hundred meters along the Equator — that is, where the ellipse is widest. Accordingly, the internal core of the Earth, which is responsible for the magnetic field of the Earth according to a currently held hypothesis, must also be displaced from the geometric center of the Earth. Dr. Barta's new theory "proves this hypothesis," according to the article. It follows from his theory that the movement of the internal core causes certain changes in the gravitational field. "Thus," the article continues, "the shape of our Earth is not permanent but changes with time." The article concludes: "A lively debate followed this paper which had given, through the new theory, an explanation to several still unanswered scientific questions." ("The Shape of Our Earth Changes"; Budapest; Magyar Nemzet, 24 Jan. 1960; p. 4).

V. GEOMAGNETISM

More on the Relationship Between Solar Flares and Geomagnetic Disturbances

Although there is no question that there is a relationship between solar activity and geomagnetic disturbances, up to the present time we have been unable to prove what particular region emits geoactive corpuscles capable of exciting the Earth's geomagnetic field. The search for such formations and regions is associated with a great number of hypotheses and theories. The most important and debatable is the question of the zones on the Sun that are responsible for the emission of geoactive corpuscles. It is difficult to point directly to a solar formation that emits geoactive corpuscles; this is because all solar elements are closely interconnected both in time and space.

One of the methods used for establishing the sources of corpuscles in the Sun's envelope is a comparison of different elements of solar activity with geomagnetic disturbances. (Barsukov then reviews the work of such researchers as Sen Gupta, Roberts and Treffer, Bednarova, Watson, Newton and Jackson, Sabben, Simon, and Pecker and Roberts)

A number of researchers feel that the streams of corpuscles from flares (in contrast to those from flocculi) are nonradial. They point out that geomagnetic disturbances occur even after flares are situated at a distance of 45° from the center of the Sun's disk. Thus, the problem of geomagnetic disturbances following chromospheric flares and the radiality of corpuscular streams from them is debatable. This in its turn causes some uncertainty in explaining the nature and velocity of corpuscular streams and the synoptics of geomagnetic disturbances.

This article makes an attempt to explain whether there is a correlation between the effect of chromospheric flares and geomagnetic activity. The data was taken for a year of high solar activity because we needed data for a large number of flares of great intensity. A detailed investigation was made of the effect of flares associated with corpuscular streams; 233 cases of flares with an intensity of 2- to 3+ were observed. The visible solar disk was divided into 8 longitudinal sections of 25 and 15°. In each section the effect of the flares was examined separately. The Table (not reproduced here) provides data concerning the distribution of the examined cases by heliographic coordinates. It is interesting to note that in 1957 east-west asymmetry was expressed by a predominance of flares on the western side of the disk.

The flares were recorded in one-hour intervals (counting from the beginning of the day) and in longitudinal sections. The method of superimposition of epochs was used to determine the mean values of the International K-index for a period of 10 days before a flare and 10 days thereafter.

Figure 2 gives graphs for each longitudinal interval. These graphs permit us to draw a number of interesting conclusions. Each of the graphs shown in Figure 2 is the result of the averaging of a relatively small number of K-indices (as indicated in the Table). A graph was also drawn for these same cases of flares by the method of superimposition; in this case, however, computation began at the moment in which the active F-region passed across the Sun's central meridian. The graphs in Figure 3 permit us to determine the time of delay more precisely because the repeated maxima shown on the graphs in Figure 2 are "smoothed out." Figure 3 also shows a graph for these same flares without taking into account their position on the Sun's disk. By comparing our Figure 3 with Sabben's (shown in Figure 1), the inadequacy of the latter becomes apparent; this is because he used the moment of the flare and not the moment of the passage of the F-region across the Sun's central meridian as the time when he began his computations.

Thus, if we assume that geoactive corpuscles only reach the Earth after the passage of the F-region across the Sun's central meridian, the mean time of delay is 3.5 days, which corresponds to a velocity of ~800 km/sec. ("Geomagnetic Effectiveness of Chromospheric Flares /Based on 1957 Data/" by O. M. Barsukov, Izvestiya Akademii Nauk SSSR, Seriya Geofizicheskaya, No. 11, 1959, pp. 1690-1693)

VI. OCEANOGRAPHY

Research on the Paleogeography of the Northwestern Pacific Ocean

In our investigations of foraminifera in the northwestern part of the Pacific Ocean we used bottom-dredged samples and cores of bottom sediments collected by expeditions of the Institute of Oceanology of the Academy of Sciences of the USSR by the vessel Vityaz' in 1953-1955. A study of the distribution of foraminifera was made for the purpose of clarifying the stratigraphy of sediments and the paleogeography of the Pacific Ocean basin.

The forms of foraminifera encountered in the cores live in the Pacific Ocean at the present time. Therefore for an understanding of their distribution in the bottom deposits we studied their present-day distribution and ecology in the northwestern part of the Pacific.

Calcareous bottom types live in coastal regions at depths of up to 2,500 m and in the open ocean in some areas at a depth up to 3,000-3,500 m (Figure 1, not reproduced here). They are not found at great depths. All the other parts of the ocean bottom, at depths from 2,500-3,500 to 9,000-10,000 m, are populated by deep-water silicious foraminifera (Figure 2 in original text).

The maps in the text showing the quantitative distribution of foraminifera are drawn on the basis of data for 250 stations. The cores of bottom sediment disclose a stratification permitting us to distinguish seven horizons.

Horizon I. The distribution of foraminifera in the upper half of this horizon corresponds to the present-day distribution of deep-water silicious forms. Downward their numbers decrease. The horizon varies from 10 to 45 cm in thickness.

Horizon II. This horizon, 60 to 215 cm thick, has been delineated on the basis of the disappearance of deep-water silicious forms and the appearance of calcareous bottom forms.

In all the cores taken from the Zenkevich and Obruchev submarine highlands and adjacent slopes of the Kurile-Kamchatka and Aleutian deep-water trenches, and also near the northern end of the submarine Hawaiian range, deep-water silicious foraminifera disappear in horizon II and a great number of calcareous bottom forms appear.

Horizon III is 100-180 cm thick. In contrast to horizon II it does not contain calcareous foraminifera, but, as in horizon I, deep-water silicious forms are present.

Horizon IV is 100-120 cm thick. Deep-water siliceous forms disappear and calcareous forms again make an appearance. Plankton foraminifera are represented by Globigerina pachyderma.

Horizon V is 100 cm thick. Foraminifera are absent. Horizon VI is 200 cm thick. Calcareous bottom forms again appear, in greater numbers than in horizon IV. Plankton foraminifera, as in horizons II and IV, are represented by Globigerina pachyderma. Horizon VII contains no foraminifera.

The differences in the distribution of foraminifera in horizons I (Holocene) and II indicate that the bottom of the northwestern part of the Pacific Ocean experienced subsidence from the end of the time of horizon II (Würm) and at the present time has attained its maximum depth.

A comparison of data on the distribution of bottom foraminifera in the northwestern part of the Pacific Ocean and Far Eastern seas indicates that at the time of horizon III (Riis-Würm) the examined region also experienced subsidence. At the time of horizons IV (Riis) and VI the bottom underwent an uplift, while at the time of horizons V and VII it experienced subsidence. ("Distribution of Foraminifera in Bottom Sediments and the Paleogeography of the Northwestern Part of the Pacific Ocean," by Kh. M. Saidova, Doklady Akademii Nauk SSSR, Vol. 129, No. 6, 1959, pp. 1401-1404)

The Influence of Thermal Processes on the World Ocean

The formation and movement of deep water masses influences hydrological conditions in the entire water body of the ocean. We now know that the overwhelming majority of the deep water masses are formed by the subsidence of surface waters. However our information about the factors leading to subsidence of immense amounts of surface water is still exceedingly limited. The role of thermal processes has remained almost completely unexplained. Our investigations of the heat budget of the surface of the world ocean has enabled us to come to several extremely interesting conclusions as to in what regions and with what intensity thermal processes exercise an influence on the formation of deep water masses. We do know that the ocean has a negative heat budget in areas where there is subsidence of surface water. In such cases the surface water is cooled, it becomes denser and sinks.

From an examination of the map of the annual heat budget of the surface of the world ocean we can see that the largest area with a negative heat budget is in the northern part of the Atlantic Ocean to the north of a line from the Straits of Florida to the Bay of Biscay.

The negative heat budget noted here may be regarded as one of the principal factors causing the so-called "deep waters" of the North Atlantic, distinguished by an exceptionally high temperature, salinity and oxygen content.

In the northern part of the Pacific Ocean the negative heat budget occurs over a smaller area and is also considerably less in absolute value; this substantially limits its role in the formation of deep waters. Subsidence occurs to a much lesser extent and does not extend to depths as great as in the North Atlantic.

The heat budget is an extremely important factor in the complex processes characteristic of the main oceanic fronts. In the area of the subpolar and polar oceanic fronts there is a pronounced decrease in the positive heat budget or an increase in the negative budget. Thus, the subsidence of surface water associated with the presence of zones of convergence caused by dynamic factors is intensified by thermal processes (cooling of the water). On the other hand, in the area of the equatorial and tropical oceanic fronts, which are characterized by a high positive heat budget of the ocean surface, thermal processes weaken the dynamic effect; this leads to subsidence of surface water. It is therefore obvious that we need a somewhat more detailed examination of the role of the heat budget of the ocean surface and of those processes which develop in the areas of the subpolar and polar oceanic fronts.

Existing data enable us to fully discuss only the heat budget for the south polar front (Antarctic convergence) which passes approximately along 50° S. in the Atlantic and Indian Oceans and 55°-60° S. in the Pacific Ocean. In this area there is a negative heat budget, attaining high values. The cooling of the water, caused by the negative heat budget, is probably the principal factor which leads to the subsidence of a considerable mass of surface water here. Before the clarification of the role of thermal processes we did not understand the cause for the formation of considerable amounts of deep waters in this region. A lack of data does not permit us to make a corresponding analysis of the oceanic polar front in the Northern Hemisphere.

In the course of the cold season of the year negative values of the heat budget predominate almost everywhere at the surface of the world ocean, with the exception of the equatorial zone and the tropical latitudes adjoining thereto. Thus, in winter in the Northern Hemisphere the heat budget is usually negative to the north of 10°-15° N., while in winter in the Southern Hemisphere it is usually negative to the south of 10°-20°, in places to the south of 5° S. In other parts of the ocean the heat budget as a rule is positive.

Within those parts of the ocean with a positive heat budget there will be an increase in the stratification of surface waters and a decrease in the extent of their subsidence in depth. On the other hand a negative heat budget leads to an increase in the homogeneity of surface waters and their subsidence; the intensity of this phenomenon will increase with an increase in the value of the negative heat budget. ("The Role of Thermal Processes in the Formation of Deep Water Masses in the World Ocean," by V. N. Stepanov, Doklady Akademii Nauk SSSR, Vol. 129, No. 6, 1959, pp. 1405-1408)

Research Ships End Atlantic Survey

The Soviet scientific research ships, Orekhovo and Oskol, are reported to have returned from a long Atlantic voyage. The research expedition, during the trip which lasted 220 days and covered about 30,000 miles, crossed the equator 6 times. The task of the expedition, which was to survey new regions for industrial fishing, was successfully accomplished. The richest accumulations of tuna, crab and shrimp were discovered and studied. ("Latest News"; Moscow, Izvestiya, 9 Feb. 1960, p. 1)

VII. SEISMOLOGY

Observation of Air Waves by Soviet Station During Mongolian Earthquake

On 4 December 1957 there was a destructive earthquake of intensity 11 in the southern part of the Mongolian People's Republic in the Gurvan-Bogdo Mountains. This earthquake has been referred to as the "Gobi-Altay earthquake" in the scientific literature. At the moment of the earthquake air waves were generated in the region of the epicenter and recorded by microbarographs at a distance of 2,440 km away.

The Gobi-Altay earthquake has been studied by a number of Soviet scientists who have studied the epicentral region in detail. Research has demonstrated that the extremely great destruction and numerous cracks, fissures, slides and faults occurred as the result of an earthquake in the Ikho-Bogdo mountain massif. The principal fissure has been traced continuously for a distance of 250 km from the Bakhar mountain massif on the west to the eastern boundaries of the Bago-Bogdo. The fissures extended to a considerable depth and cut through both loose sediments and crystalline rocks.

As a result of the earthquake the Ikho-Bogdo mountain massif, about 100 km long and up to 3,790 m high, was moved 3-3.5 m eastward and uplifted 2-6 m. The earthquake focus was evidently situated in the limits of the upper part of the earth's crust.

It is impossible to determine the depth of the focus from instrumental seismic data because there are no seismic stations near the epicenter.

The intensity M was determined from surface waves by many seismic stations in the world and rated in intensity from 7 3/4 (USSR) to 8.6 (Pasadena). The time at the focus and the coordinates of the epicenter are given in Table 1 (not reproduced here).

This article gives a brief description of the apparatus used at the station recording the air waves and a description of the character of the recordings of air waves registered at this station.

At the temporary station, situated 2,440 km to the southeast of the epicenter, in addition to microbarographs there were also two three-component electrodynamic seismographs with different constants and two low-sensitivity horizontal seismographs with a magnification on the order of 5 and 20. The character of the recordings on the seismograms registered by these three instruments was different.

The recording of air waves was made at a distance of 2,440 km from the epicenter on electrodynamic microbarographs, types EDMB-I and EDMB-II with galvanometric recording. These waves were not recorded by microbarographs at seismic stations situated at a greater distance from the

epicenter. Figure 1 shows a recording of the air waves over a period of somewhat less than 10 minutes. The energy of the waves was on the order of 10^{17} ergs, 10^7 times less than the energy liberated in the form of elastic seismic waves. The velocity of propagation of the air wave was v_B = 320 m/sec; with an error of 1-1.5% this coincides with the values for velocities of air waves observed during explosions of volcanoes, meteorites and hydrogen bombs.

On the basis of our data we may conclude that air waves arose at the epicenter at the moment of the earthquake and were evidently caused by powerful dislocations — fissuring in the earth's crust.

During earthquakes in the Aleutian Islands with an intensity matching that of the Gobi-Altay earthquake, air waves were not recorded by microbarographs. This may be related to the deeper location of their foci, their situation beneath the bottom of the ocean and the considerably greater epicentral distances. ("Air Waves Arising at the Time of the Gobi-Altay Earthquake of 4 December 1957," by I. P. Pasechnik, Izvestiya Akademii Nauk SSSR, Seriya Geofizicheskaya, No. 11, 1959, pp. 1687-1689)

Microseismic Activity in the Caspian Basin

The seismic stations of the Caspian coast record microseisms with a period of 2-4 seconds, sometimes attaining considerable intensity (12μ). The purpose of the present work is the finding of a correlation between meteorological conditions and the intensity of microseismic activity and the finding of the foci of these microseisms.

To analyze this activity use was made of data from six seismic stations, weather maps at a scale of 1:5,000,000 and composite weather maps at a scale of 1:10,000,000. The Table (not reproduced here) gives a statistical characterization of microseismic activity depending on a series of criteria.

An analysis of these data shows that the microseisms of the Caspian area are of local origin and are caused by small cyclones moving out onto the Caspian Sea. The intensity of microseismic activity increases when these cyclones are combined with atmospheric fronts.

Recording of microseisms at seismic stations should begin at the moment when the western part of the cyclone passes onto the sea; this corresponds to a wind shift of 180°, and the formation of a standing wave in accordance with the Longuet-Higgins theory of microseisms.

The source of the most intense microseisms is the western part of the Derbent depression and the maritime region of Derbent; this is because a combination of atmospheric fronts and cyclones arises on the northern slopes of the Caucasus mountains. ("On the Nature of Microseismic Activity in the Caspian Basin," by V. N. Tabulevich, Izvestiya Akademii Nauk SSSR, Seriya Geofizicheskaya, No. 11, 1959, pp. 1694-1698)

A New Highly Sensitive Seismoscope

This article describes in great detail the operation and working principles of the LS-1 high-sensitivity laboratory seismoscope; the instrument makes it possible to simulate low-intensity wave processes with great accuracy.

The principal difference between this seismoscope and existing models of laboratory seismoscopes is its greater sensitivity. In comparison with the UZS-2 seismoscope (in production) the total sensitivity of the LS-1 instrument has been increased 1'75 times in the 70-230 kilocycle frequency band. Since the beginning of 1958 this seismoscope has been successfully used at the Institute of Physics of the Earth of the Academy of Sciences of the USSR for the study of dynamic peculiarities of low-intensity waves. Figure 6 shows the example of two seismograms made during one and the same experiment using the UZS-2M and the LS-1 in which the superior sensitivity of the latter is clearly apparent; the recordings made on the new instrument can be read more accurately and easily.

A working model of the LS-1 highly-sensitive laboratory seismoscope has been developed and manufactured.

The coefficient of magnification of the amplifier is $28 \cdot 10^6$ with a pass band with a frequency of 4-310 kc; the amplitude of output electrical impulses is 1,200 v. ("The LS-1 High-Sensitivity Laboratory Seismoscope," by V. A. Obukhov, Izvestiya Akademii Nauk SSSR, Seriya Geofizicheskaya, No. 11, 1959, pp. 1625-1635)

Seismic Exploration in China

In the fall of 1958 the authors of this article, A. M. Yepinat'yeva and I. P. Kosminskaya, had an opportunity to become familiar with the work of scientific-research and professional organizations associated with seismic exploration in the Chinese People's Republic. The Geophysical Institute of the Academy of Sciences of the CPR organized a field trip for a group of geophysicists and the authors participated. They became familiar with work carried on in various regions in China

and convey this information to the reader in some detail. They discuss the methods currently being used by Chinese field workers and discuss the reasons for some failures or uncertain results that have resulted from work in some regions.

Seismic exploration work for petroleum and gas is conducted by the Ministry of the Petroleum Industry and Geology. The principal method for seismic exploration is the method of reflected waves; the correlation method of refracted waves is presently used only on a small scale. The primary objective of seismic exploration in all regions is the search for petroleum bearing structures. In regional work the problem is the choice of the most promising areas for detailed exploration. In seismic work use is made primarily of Soviet seismic stations type SS-26-51D and Chinese seismic stations manufactured at the Geophysical Instrument Plant in Sian, based on the SS-26-51D. The seismographs used are of the SP-16 type.

For 1½ months the authors travelled on expeditions sponsored by the Ministry of the Petroleum Industry and the Ministry of Geology. In addition to the significant details of a technical nature concerning various regional problems (not reported on in this summary), they provide information on the scientific-research institutions in the CPR that have sections devoted to geophysical methods of exploration.

These include the Geophysical Institute of the Academy of Sciences of the CPR with a section on geophysical methods of exploration; this section has several groups: seismic, gravimetric, and electro-exploration. The principal task of this organization is bringing about an increase in the geological and economic efficiency of seismic exploration applicable to different regions in the country characterized by different seismogeological conditions.

The Geophysical Division of the Academy of Petroleum of the Ministry of the Petroleum Industry is another such organization; the Academy of Petroleum was organized in 1958. There are five groups in the Division: seismic, electrical core sampling, radioactive methods of exploration, magnetic, and a group for generalization. The chief task of the seismic group is the development of methods for the solution of difficult exploration problems and the improvement and construction of apparatus.

The Scientific-Research Geophysical Institute of the Ministry of Geology has the following sections: geophysical, geochemical and aero- and mining geophysics. The main assignment of the Institute is the mastery of the latest techniques in the field of geophysical and geochemical methods of exploration and the development of new methods applicable to the exploration of ore deposits.

The geological-geophysical and seismological-geological conditions of a number of regions of China are very similar to individual regions in the USSR, there is much in common in seismic data, in methodological difficulties and problems of a scientific character. This, the authors say, is a solid basis for contact between the USSR and China.

From the tempo at which all branches of science and the national economy are now developing in China, they add, it is clear that after some years China will become one of the leading countries in the field of geophysics. ("Seismic Exploration in China," by A. M. Yepinat'yeva and I. P. Kosminskaya, Izvestiya Akademii Nauk SSSR, Seriya Geofizicheskaya, No. 11, 1959, pp. 1673-1683)

Earthquake Near Soviet-Afghan Border

A late-news bulletin in the 20 February Izvestiya carries a report of an earthquake in the region of the Soviet-Afghan border. The earthquake was recorded on 19 February by Uzbekistan seismic stations. The epicenter was 50 kilometers south of Khorog [southeast of Stalinabad]. Strength at epicenter was estimated to have had an intensity of 6-7. ("Latest News"; Moscow, Izvestiya, 20 Feb. 1960, p. 1)

The intensity of the earthquake recorded in Tashkent was 4. (Moscow, Pravda, 20 Feb. 1960, p. 4)

VIII. ARCTIC AND ANTARCTIC

Assault on Antarctica Continues

The Fifth Soviet Scientific Expedition recently departed from Leningrad for Antarctica aboard the diesel-electric motorship Ob. Its task is the study of the central part and coastline of Eastern Antarctica, geological research in Queen Maud Land and compilation of a geologic map of this region. The bases for this work are the observatory at Mirnyy and the stations of Vostok, Komsomol'skaya and Lazarev deep in the interior. Plans call for the establishment of several temporary aerometeorological stations on the coastline and in the interior and the organization of expeditionary journeys with sledge-tractor trains.

Among the participants are the airmen Pimenov, Vechtomov, Zotov, Sysoyev, Safonov and others.

Aleksandr Nikolayevich Pimenov has flown for many years in the Arctic, has participated in high-latitude expeditions and possesses experience in the selection of landing areas. No less experienced is Anatoliy Barabanov -- a repeated participant in Antarctic expeditions. Others who have been in Antarctica are the airforce radiomen Boyko and Aleksandrovskiy and airforce mechanics Gladkov, Mezhevykh and Avan'yev. Their knowledge and experience will assist researchers in the study of the sixth continent.

The air detachment is charged with a complex and responsible task -- that of insuring permanent communication between Mirnyy and all the Soviet stations which are situated at great distances away. The aviators are also charged with supplying the sledge-tractor trains and the scientific workers in the Queen Maud Mountains. They will make airdrops to field parties, assist in the organization of scientific stations and make aeromagnetic surveys. ("The Assault on Antarctica Continues," by M. Filipenin, Grazhdanskaya Aviatsiya, No. 1, January 1960, p. 11)

Soviet Planes Begin Aerial Survey of Arctic Ice Conditions

Two airplanes have been flown from Leningrad into the western and eastern sectors of the Arctic in the region of the northern seas with the end of the polar night. On board the planes are associates of the Arctic and Antarctic Institute. They will conduct the first aerial ice survey of the current year. A report from the Institute states that the planes have arrived in the Arctic and have begun operations. ("First Aerial Survey of Ice"; Moscow, Sovetskaya Aviatsiya, 19 Feb. 1960, p. 4)

Lazarev-Mirnyy Flight Made Under Adverse Conditions

A report from A. Pimonov, Commander of the aviation detachment of the Fifth Antarctic Expedition, describes the recent flight from station Lazarev to the observatory Mirnyy. The Li-2 used in the flight left Lazarev on 11 February with 12 men on board.

Low clouds, poor visibility, and head winds reaching 100 kilometers an hour, were encountered along the route.

The first landing for refueling was made at the Japanese station of Showa, and the second at the Australian station of Mawson.

The Li-2 landed at Mirnyy on 15 February, having covered a distance of 3,600 kilometers in 21 hours flying time.

The crew consisting of A. Baranov, commander and I. Vechtomov, Ya. Perevezentsev, B. Danilov, and B. Aleksandrovskiy, displayed real heroism and a high degree of flying skill during the flight.

At present the entire aviation detachment is concentrated at the airdrome at Mirnyy and is occupied in supplying the intracontinental station, Vostok. ("Lazarev-Mirnyy Flight"; Moscow, Sovetskaya Aviatsiya, 20 Feb. 1960, p. 4)

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